





Introduction

- Richard W. Wortley, President
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- Hextek Corporation, Tucson AZ
 - Mirror substrate manufacturer
 Light weight Borosilicate structures
 24 years in operation
- Program: Manufacture the JWST ACF test flats
- Funding Agency: NASA
 - Corporate Partner: ITT Geospatial Systems



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Criteria for Hextek Gas-Fusion Substrate Selection

- Good thermal stability of the glass at the JWST cryogenic test temperatures

- Rapid fabrication time
- Standard optical finishing techniques
- Easy to handle







JWST Cryogenic Test Configuration Johnson Space Flight Center

Auto collimating Flat Mirrors (ACF Assembly)

• 3 ACFs (actuated motion)

- Test program starts 2012
- Six months of testing
- Three mirrors used for testing

Optical Telescope Element (OTE Integrated Science Instrument Assembly (ISIM) – (OTIS)

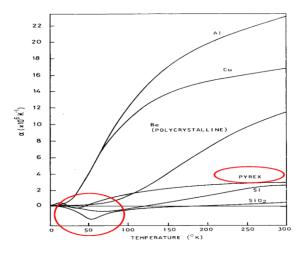


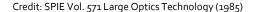


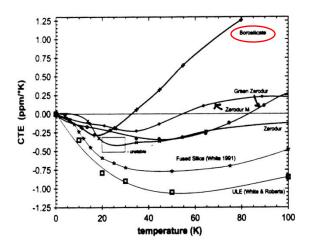




Comparison of Coefficient of Thermal Expansion of Borosilicate Glass and Other Optical Materials at Low Temperatures







Credit: S.F. Jacobs, Optica Acta, 1986, Vol. 33, No. 11, 1377-1388







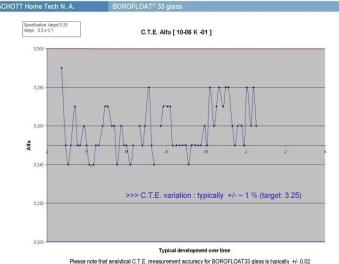
Borofloat® 33 Technical Data Face Sheet Material

- Factory Supplied Plate Dimensions
 - Typical 2300mm x 1700mm
 - Up to 2300m x 2300mm
 - Thickness Range: 0.7mm 25.4mm

Mechanical Properties
Density (25°C) ρ 2.2 g/cm3
Young's Modulus E 64 kN/mm2
Poisson's Ratio μ 0.2
Knoop Hardness HK0.1/20 480
Bending strength σ 25 MPa

Thermal Properties Coefficient of Linear Thermal α (20–300 °C) 3.25 × 10–6 K–1 Specific Heat Capacity cp (20–100 °C) 0.83 KJ × (kg × K)–1 Thermal Conductivity λ (90 °C) 1.2 W × (m × K)–1





The values given above serve as orientation values





SNA/CG - 03/17/2008





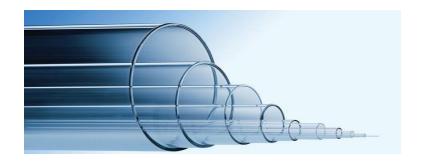


Duran® Tubing Technical Data Core Structure

- Factory Supplied Tube Dimensions
 - Diameter range 3mm 325 mm
 - Wall Thickness Range 0.7 mm 10 mm
 - Length = 1500mm

Mechanical Properties
Density (25°C) ρ 2.23 g/cm3
Young's Modulus E 63 kN/mm2
Poisson's Ratio μ 0.2
Knoop Hardness HK0.1/20 480
Bending strength σ 25 MPa

Thermal Properties Coefficient of Linear Thermal α (20–300 °C) 3.3 x 10-6 K–1 Specific Heat Capacity cp (20–100 °C) 0.83 KJ x (kg x K)–1 Thermal Conductivity λ (90 °C) 1.2 W x (m x K)–1



Example for the Mean Linear coefficient of expansion for DURAN® and SCHOTT-BORO-ARTISTIC™

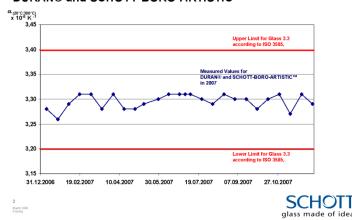










Plate and Test Sample Cut-Diagram

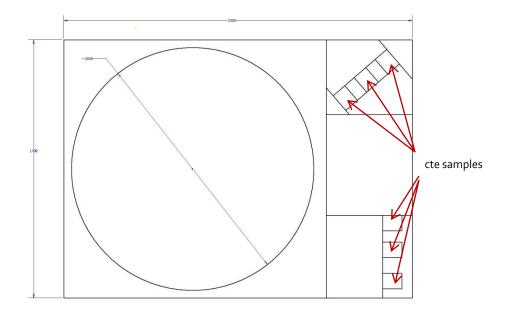














Plate and Tube Sample CTE Testing

- ATK Interferometric Metrology Facility (IMF)
 - 6 inch clear aperture into 24" diameter vacuum chamber
 - Temperature range <20K to >400K
 - 1.5 Watt at 4K cryo-cooler for sustained cryogenic temperature capability to <20K
 - Test chamber is nominally 10" diameter
 - 12 interferometer channels
 - 24 channels of specimen temperature sensing via NIST traceable diodes





Photos Courtesy ATK



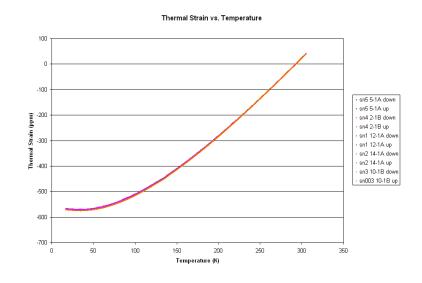


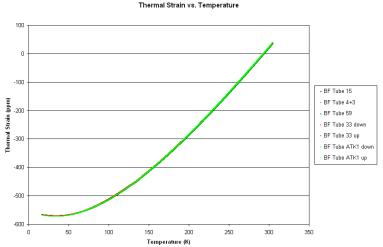




ATK Strain Measurements Borofloat 33 & Duran Samples

- Test cycle time ~ 60 hrs
- No. of samples tested: 5 each
- Lowest Temperature 16°K
- Accuracy and uncertainty ~ 20 ppb
- Excellent repeatability
- Maximum difference between samples at 16°K ~ 0.8 ppm







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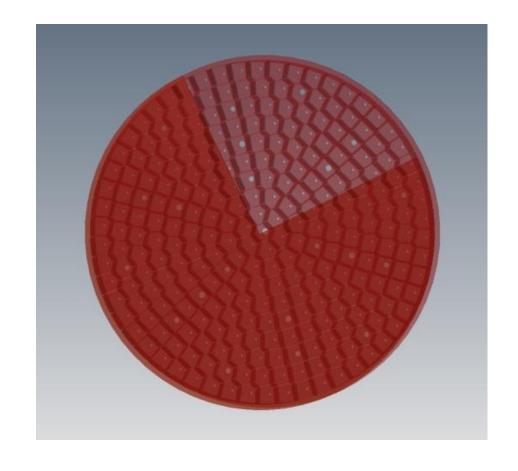






Blank Dimensions

- Diameter
 - Face Plates: 1600mm
 - Core: 1560mm
- Thickness
 - Overall: ~200mm
 - Face Sheets 15mm
- Total Number of Cells: 291
- Mass
 - Total~ 182 kg
 - Face Sheets ~ 148 kg









Gas-Fusion Process



- Abrasive water-jet cut face plates ITT/AGI
- Cut core tubing Hextek
- Load glass in furnace ~ 1 week
- Gas-Fusion cycle ~ 12 hrs
- Anneal
 - Zonal temperature control <1°C</p>
- Clean & Inspect
- Total Furnace Time ~ 3 weeks















ITT Optical Fabrication

- **Production Cycle**
 - ~ six weeks to finish to ~10-waves p-v
 - Produce cryogenic & support deflection map
 - Cryogenic and Support deflection removal
 - Ion figuring







Edging Blanchard Grinding Face Plate



Polish & Figure

Photos Courtesy ITT Space Systems Division



Hextek Corporation

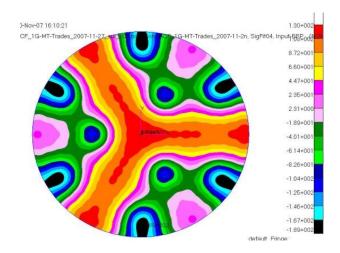






Basic ITT Support Design

- Basic "Wiffle-Tree" Design
 - face down configuration
 - 9-point support
 - ~318 nm p-v to be removed
 - Ion figure to correct gravity deflection



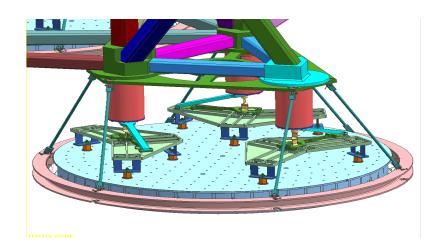








ITT 9-Point Support Design





9-Point Model

Mount to Back Plate Attachment

Courtesy ITT Space Systems Division









ITT "Toggle Bolt" Mount Interface







Toggle closed

Toggle Pads Deployed

Toggle in Position

Photos Courtesy ITT Space Systems Division







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Integration of Mount Subassembly to Mirror



Mirror-to-Mount Interface



Wiffle-Tree Attachment

Hextek Corporation

Photos Courtesy ITT Space Systems Division







Cryogenic Test on First ACF & Mount Subassembly

- Test Temperature Controlled to 32.8K
- Total Cycle Time: ~ one week
- Results:
 - Minimal ambient to cryo figure shift



Mirror & Subassembly in Cryogenic Test Chamber

Photos Courtesy ITT Space Systems Division







Current Status of ACF Production

- Total number of ACF blanks ordered: 4
- Blanks delivered: 3
- In process prep for preliminary polish: ACFs#1,2,3
- Initial polish and figure completed: ACF# 1
- Mounted and tested cryogenically: ACF#1
- Ion figure cryo-correction: ACF#1
- ACF #4 delivery by Hextek to ITT by mid July 2010